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(54) Title: LIQUID FOR EVAPORATIVE COOLING APPARATUS

(57) Abstract

The invention relates to a liquid for evaporative cooling, said liquid being particularly suitable to indirect evaporative cooling apparatus. The liquid comprises an aqueous solution of trimethyl glycine, preferably containing 5-35 wt.% trimethyl glycine or a derivative thereof, and 65-95 wt.% water.

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## Liquid for evaporative cooling apparatus

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The present invention relates to a liquid for evaporative cooling, the liquid being especially suitable to indirect evaporative cooling apparatus.

10

In general, evaporative cooling systems and apparatus use a cooling liquid that is sprayed to the object being cooled. Spray cooling is for instance used in technical building services, particularly in air conditioning equipment. At present, the most common liquid for this purpose is water since it is safe to use and odorless, and further, its heat transfer properties are good. The use of water is, however, limited by the fact that it freezes already at 0°C.

15

Anti-freezing agents like ethylene and propylene glycols are not preferable since they cause corrosion problems, and since an unpleasant odor is released as they evaporate into the air stream being circulated. In addition, their viscosity is high and they are quite toxic.

20

Cooling liquids are commonly used in industry, technical building services, refrigerating apparatus, as well as in engine applications. Adequate heat transfer characteristics are an important feature of such cooling liquids. A high specific heat capacity, and sufficient thermal conductivity and pumpability properties thereof are necessary for this. Liquids are characterized by a low viscosity at low temperatures, allowing a turbulent liquid flow to be provided using less pumping power.

25

In addition to the above properties, preferable cooling liquids are characterized by the fact that they are nonpolluting and nontoxic, particularly in food industry and service water applications. A cooling liquid may in no way be deleterious to the product being processed. Otherwise even minor leaks of the liquid into the process

30

could cause serious accidents. Therefore, the nontoxicity is a decisive factor when choosing the cooling liquid.

5 With respect to most of the properties water, it is an almost ideal heat transfer liquid. The heat transfer and pumpability properties thereof are good. Further, water is perfectly non-toxic and safe to the environment, as well as completely non-inflammable. The major disadvantage of water is the fact that it may be used in a very narrow temperature range. As is well known, water freezes already at 0°C and boils at 100°C. Moreover, water is corrosive, especially when in contact with  
10 materials containing iron.

Most typical water based cooling liquids are aqueous mixtures of ethylene glycol, propylene glycol, and ethanol. Ethylene glycol is one of the most common cooling liquids and it is especially used in various automobile industry applications.  
15 Disadvantages of ethylene glycol are, however, its toxicity and its polluting character. Accordingly, propylene glycol is often used instead of ethylene glycol in applications where nontoxicity is required. Even though propylene glycol is relatively nontoxic, it is, however, also environmentally questionable. Another drawback of propylene glycol is that its viscosity increases significantly at low  
20 temperatures, making a higher pumping power necessary.

Compared to ethylene glycol, the lower toxicity of ethanol makes it a preferable cooling liquid. However, the use of ethanol is limited by the high volatility thereof, and as a consequence the liability thereof to catch fire, as well as the great viscosity  
25 increase at low temperatures, this viscosity increase being, however, less significant than with propylene glycols. For this reason, ethanol is widely used as a coolant in laboratories and in applications where nontoxicity is demanded. A problem eventually associated to the use of ethanol is the required approval by the health authorities, thus making its use as a cooling agent more difficult.

30

An object of the present invention is to provide a liquid for evaporative cooling, this liquid being particularly applicable to indirect evaporative cooling systems and

apparatus, and by means of which it is possible to solve the problems associated with the state of the art and to eliminate the disadvantages thereof.

Further, an object of the invention is to provide a evaporative cooling liquid useful  
5 at low temperatures, the use thereof being environmentally safe, economical, and without any risk to the health.

The evaporative cooling liquid is characterized in the appended claims.

10 Among the essential properties of a liquid used for evaporative cooling are a small droplet size and a low temperature thereof. Small droplets increase the heat transfer surface area between the liquid and the gas surrounding it, whereas a great temperature difference increases the heating/cooling efficiency.

15 According to the present invention the preferable compound useful as a component of the evaporative cooling liquid is trimethyl glycine or the salts of trimethyl glycine hydrate. Trimethyl glycine, or betaine, is particularly preferable. Betaine may for instance be prepared by extracting from natural products such as from sugar beets, or by a biochemical process thus allowing the production of a biological evaporative  
20 cooling liquid with a favorable life cycle.

The liquid used in the evaporative cooling systems of the invention, which are preferably indirect, comprises 5—35% (weight by weight) trimethyl glycine or a derivative thereof, and 65—95 wt-% water.

25

The advantages of this evaporative cooling liquid are the nontoxicity, safety, and the lack of odor. It has the same physical properties as glycol solutions, and it is applicable at temperatures between -20 and +100°C. It is preferably used at temperatures ranging from -15 to +80°C. Trimethyl glycine, or betaine, decreases  
30 the size of the water droplet, propably because of the effect of the hydrophobic methyl end, as well as the hydrophilic acid end of the trimethyl glycine molecule. This allows the use of the liquid at temperatures below 0°C.

If necessary or desired, the evaporative cooling liquid of the invention may be combined with conventional corrosion inhibitors, stabilizing and marker agents, and other additives well known in the art.

- 5 The evaporative cooling liquid of the invention is less toxic and less polluting than the cooling liquids already known in the art. The liquid is not classified as a hazardous waste, and it may easily be disposed of, thus lowering the costs. The waste liquid may be handled without any special measures, and it may be absorbed into the earth or drained into the sewer, whereas ethylene and propylene glycols, as well as ethanol used in the state of the art must be disposed of in a special way as hazardous wastes, or under the supervision of the authorities in charge.

The evaporative cooling liquid of the invention is useful in various evaporative cooling applications, particularly at low temperatures and in situations where the liquid must be environmentally friendly and nontoxic.

The evaluation of the toxicity of the compounds is based on the LD<sub>50</sub> values from the literature. The LD<sub>50</sub> values used are tested orally with rats. The results are shown below in table I

20

Table I

Compound	LD <sub>50</sub> /mg/kg
Ethylene glycol	4 700
Propylene glycol	20 000
Ethanol	7 060
Trimethyl glycine	11 179

25

In Table II the kinematic viscosities of the liquids are compared at the concentration corresponding to the freezing point of -15°C. The freezing point is defined as the temperature at which first crystals appear in the solution.

5

**Table II**

Liquid	Concentration % by weight	Kinematic viscosity, mm <sup>2</sup> /s			
		20°C	0°C	-10°C	-15°C
Ethylene glycol	30.5	2.1	4.3	6.5	8.2
Propylene glycol	33	3.3	7.8	14.4	20
Ethanol	24.5	2.5	5.9	10.9	15.8
Trimethyl glycine	35	2.1	5.1	11	17.2

10

15 Table III below shows the effect of trimethyl glycine on the freezing point of aqueous trimethyl glycine solutions.

**Table III**

Concentration of trimethyl glycine	Freezing point, °C
5	-0.9
10	-2.1
20	-5.1
25	-7.2
30	-10.7

20

25

The surface tensions of typical heat transfer liquids are presented below in Table IV. The surface tension of trimethyl glycine is comparable to that of water, and higher than with glycols.

5

**Table IV**

10

Solution	Surface tension, mN/m
Water	72
Ethylene glycol (50 wt-%)	55
Propylene glycol (50 wt-%)	45
Trimethyl glycine solution (35 wt-%)	72
Trimethyl glycine solution (50 wt-%)	76

15

Table V shows the vapor pressures of several heat transfer liquids at 37.8°C. Since the vapor pressure of the trimethyl glycine solution is lower than with other solutions, it is not evaporated/volatilized so easily by an air stream.

**Table V**

20

25

Solution	Vapor pressure, Pa (at 37.8°C)
Water	6.1
Ethylene glycol (50 wt-%)	5.5
Propylene glycol (50 wt-%)	5.2
Trimethyl glycine solution (35 wt-%)	5.4
Trimethyl glycine solution (50 wt-%)	4.1



The solution of the invention containing 5—35 wt-% trimethyl glycine, or a derivative thereof, and 65—95 wt-% water, may be used in evaporative cooling systems, particularly in an indirect evaporative cooling apparatus.

5 Figure 1 presents a typical evaporative cooling apparatus where an indirect humidity cooling is combined with a mechanical refrigeration. Fresh air enters at 1 and is fed to a heat recovery means 2 that cools down the fresh air and refrigerates the exhaust air. The reference numeral 3 illustrates the mechanical refrigeration, 4 illustrates mechanical ventilation pumps, and 5 refers to the incoming air. The reference  
10 numeral 6 stands for the exhaust air that is fed to the evaporative cooling apparatus 7, and then to the heat recovery means 2. Thereafter the refrigerated exhaust air is ejected from the system through the mechanical ventilation pump 4. Indirect humidity cooling is combined with mechanical refrigeration to reduce the need for the latter. The idea of the indirect humidity cooling is to humidify the exhaust air,  
15 thus lowering the temperature thereof. The temperature of the fresh air is lowered with the aid of the cooled exhaust air in the heat recovery means. If necessary, the incoming air is further warmed up mechanically. The mechanical refrigeration alone consumes about 3—4 times more energy than the combination of the indirect cooling and mechanical refrigeration.

20

Trimethyl glycine is a nontoxic and odorless, naturally occurring raw material. It lowers the freezing point of water, it has excellent heat transfer properties, unpleasant odors are not released from it, and it may be used without any corrosion inhibitors to prevent corrosion since it is as such only weakly corrosive. An  
25 important advantage of using trimethyl glycine solution in spray cooling apparatus is the low temperature of water which increases the cooling efficiency. Accordingly, the system may be used for cooling air at temperatures near 0°C, for instance in refrigerated storehouses where the temperature of the air thus drops to a value below 0°C. Further, the fact that trimethyl glycine is odorless and forms droplets easily  
30 due to its high surface tension makes the use thereof very attractive.

The invention is described above with reference to some preferable embodiments thereof, the details of which should not, however, be considered as narrowly limiting the invention. On the contrary, many modifications and variations are possible within the scope and spirit of the invention defined in the appended claims.

## Claims

1. Use of a liquid in evaporative cooling systems, **characterized** in that the liquid comprises an aqueous trimethyl glycine solution.

5

2. The use according to claim 1, **characterized** in that the liquid contains 5—35 wt-% trimethyl glycine or a derivative thereof, and 65—95 wt-% water.

3. The use according to claim 1 in cooling systems, wherein said liquid is directly  
10 sprayed into the air being cooled and/or onto a heat transfer surface cooling air.

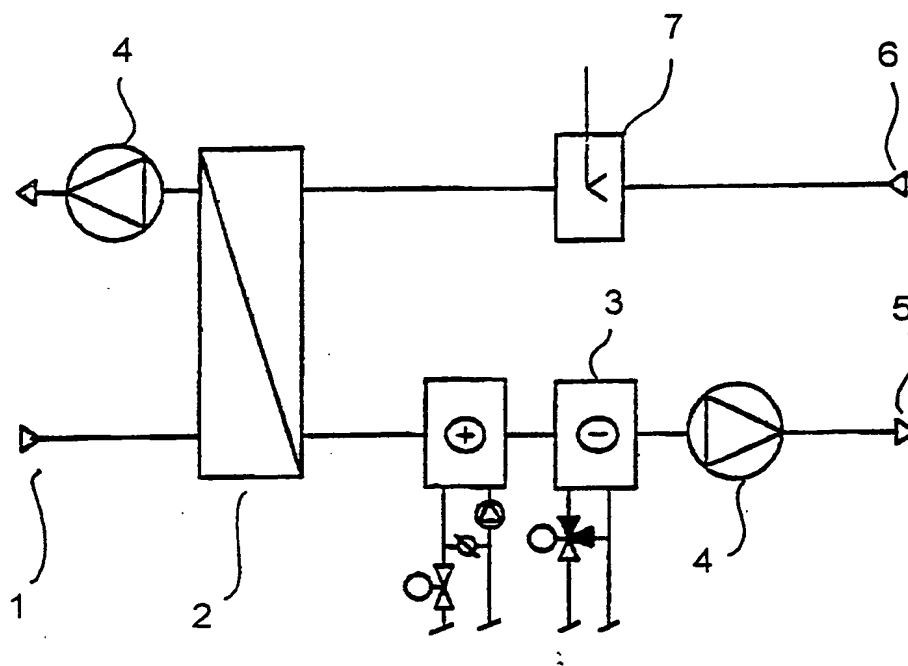


Fig. 1

1  
INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 98/00664

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C09K 5/04

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 9731988 A1 (NESTE OY), 4 Sept 1997 (04.09.97), claim 1  --	1-3
A	DE 1044843 B (SIEMENS-ELECTROGERÄTE AKTIENGESELLSCHAFT), 27 November 1958 (27.11.58), claim 1  --	1-3
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Patent document cited in search report			Publication date	Patent family member(s)		Publication date
WO	9731988	A1	04/09/97	AU	1882397 A	16/09/97
				FI	99260 B,C	15/10/97
				FI	960971 D	00/00/00
-----						
DE	1044843	B	27/11/58	NONE		
-----						
EP	0379175	A1	25/07/90	AT	123053 T	15/06/95
				AU	632785 B	14/01/93
				AU	4855790 A	26/07/90
				CA	2007912 A	18/07/90
				CN	1044292 A	01/08/90
				DE	69019539 D,T	21/09/95
				ES	2072319 T	16/07/95
				JP	2269195 A	02/11/90
				MX	166332 B	29/12/92
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